



Water Conservation Options for Wet-Cooled Power Plants

Alan Benefiel

John S. Maulbetsch

Michael N. DiFilippo

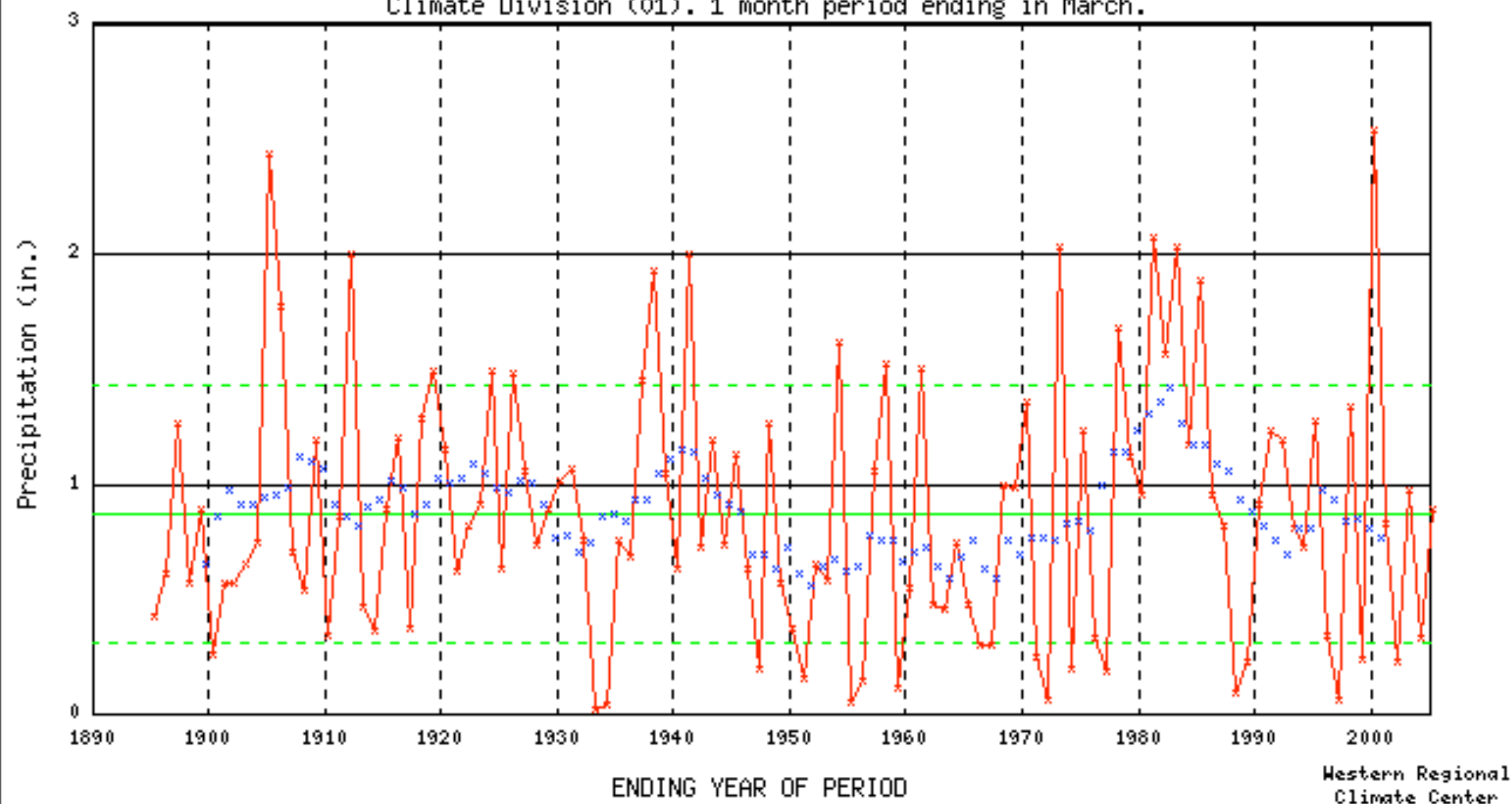
**CEC/EPRI Advanced Cooling Strategies/
Technologies Conference**

Sacramento, California

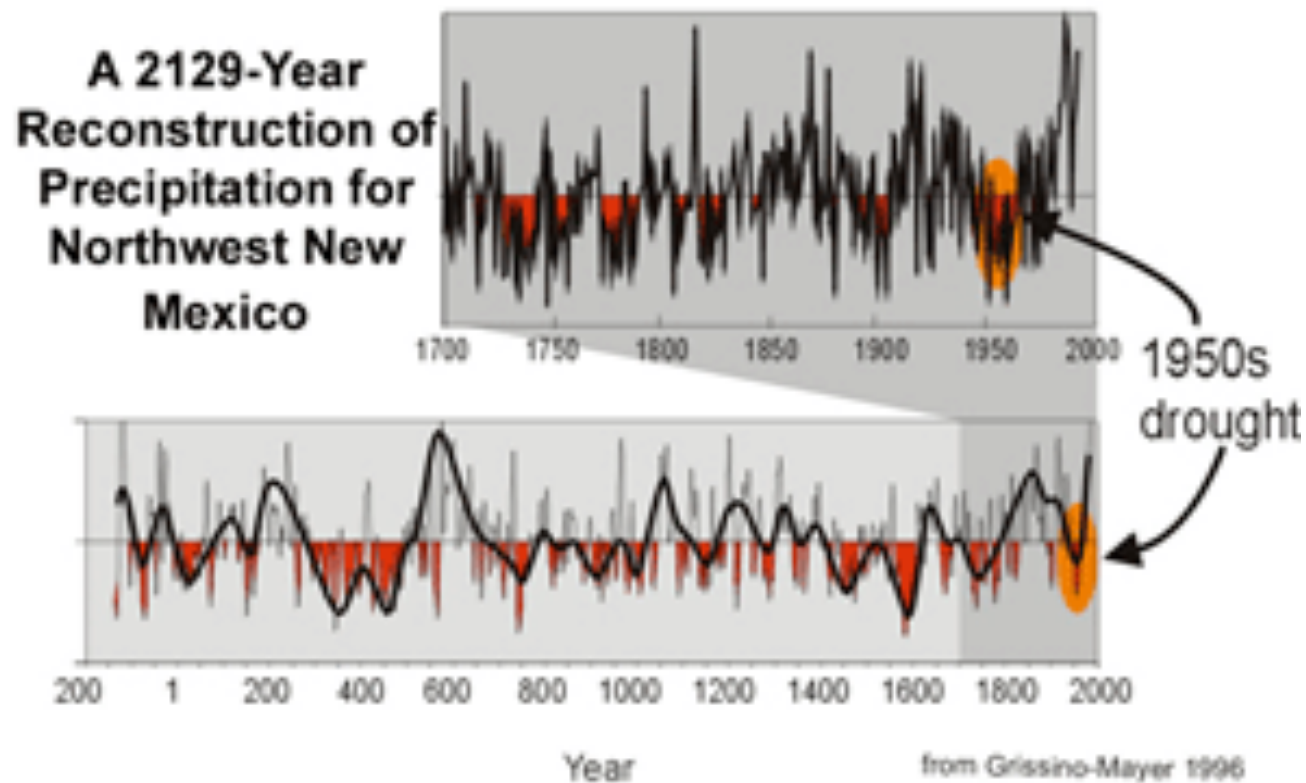
May 31---June 2, 2005

Northwestern Plateau Division, New Mexico Precipitation (in.)

Climate Division (01). 1 month period ending in March.



Paleo-Climatic Record







Water Use at San Juan

- **Units 1, 2 & 4 Cooling Towers**
 - **Approx. 16,000 acre-feet/year**
- **Objective**
 - **Save 10 to 30%**
 - **Reduction of 1,500 to 5,000 acre-feet/year**

Approaches

- **Modify wet tower operation**
- **Add supplemental dry cooling**
- **Use alternative, “non-fresh” water sources**

Evaluation

Evaluate on basis of

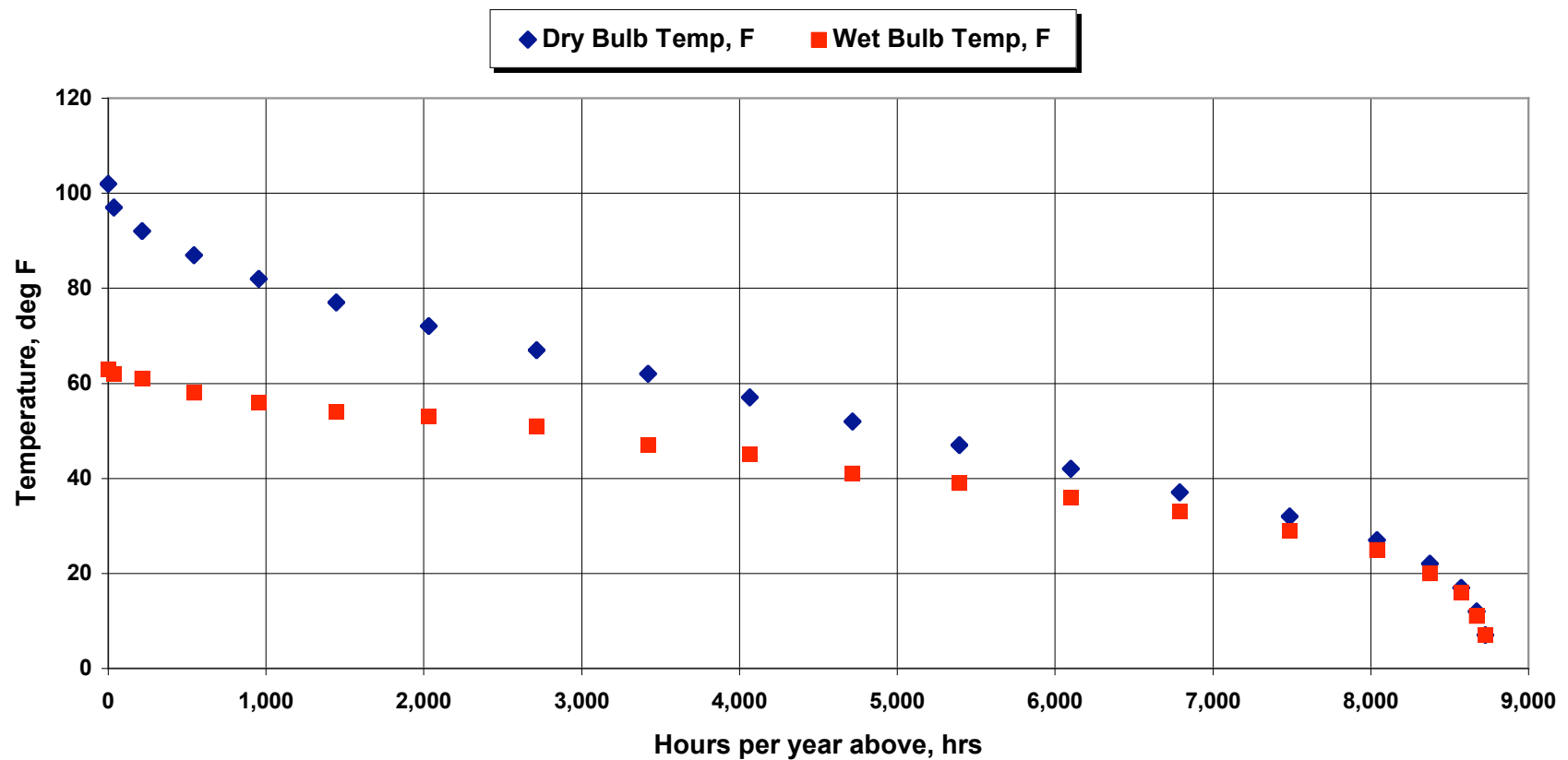
- **Capital cost**
- **Operating cost (fans/pumps)**
- **Effect on plant**
 - **Cold water temperature**
 - **Turbine backpressure**
 - **Heat rate**
 - **Coal used**
 - **Lost revenue**
- **Total evaluated cost**

Starting Points

- **Site meteorology**
- **Current water use profile**
- **Current cold water temperature profile**
 - **Turbine heat rate**
- **Economic assumptions**

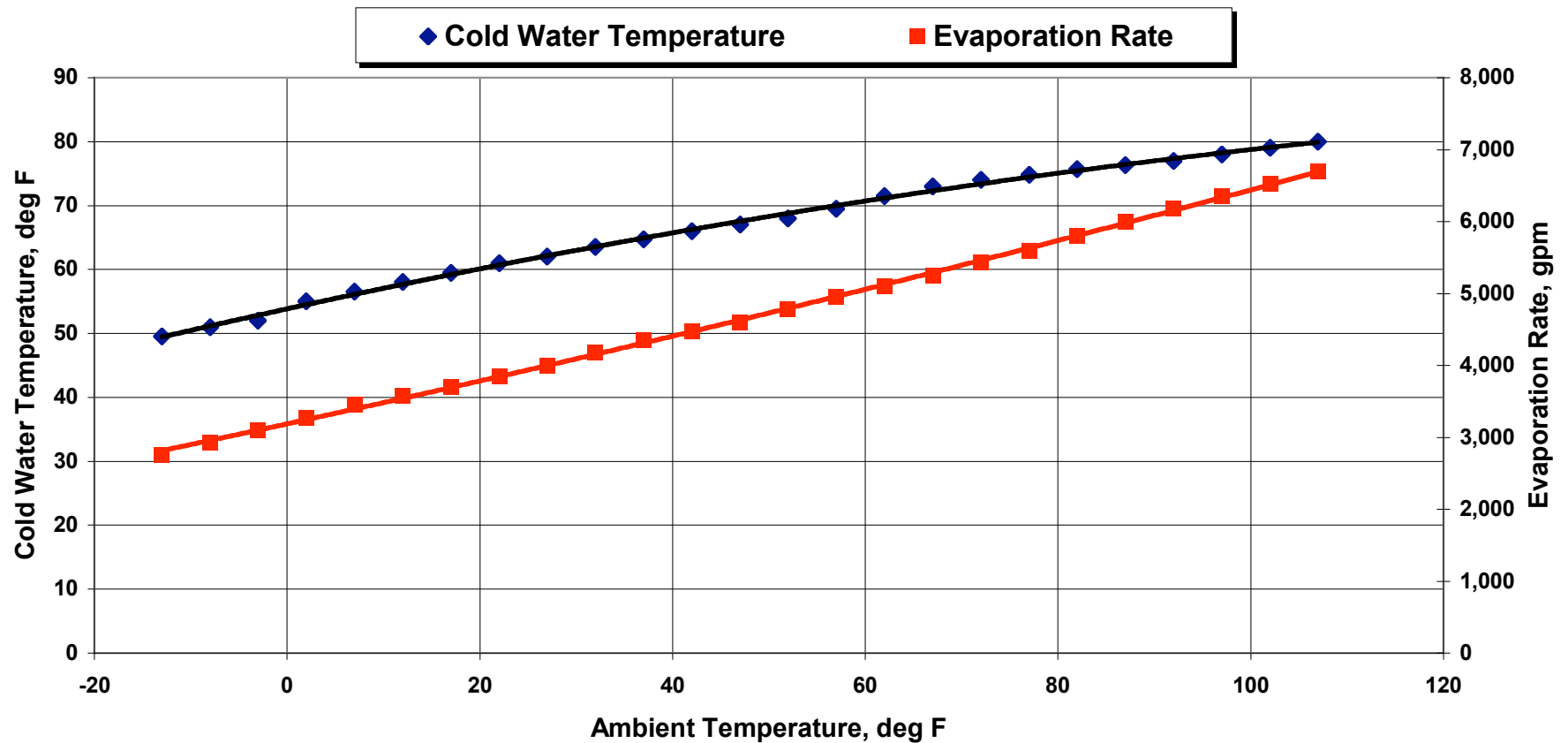
Temperature Duration Curves

San Juan Temperature Duration Curves



Water Use & Cold Water Temperatures

Unit 4 Existing Tower Performance

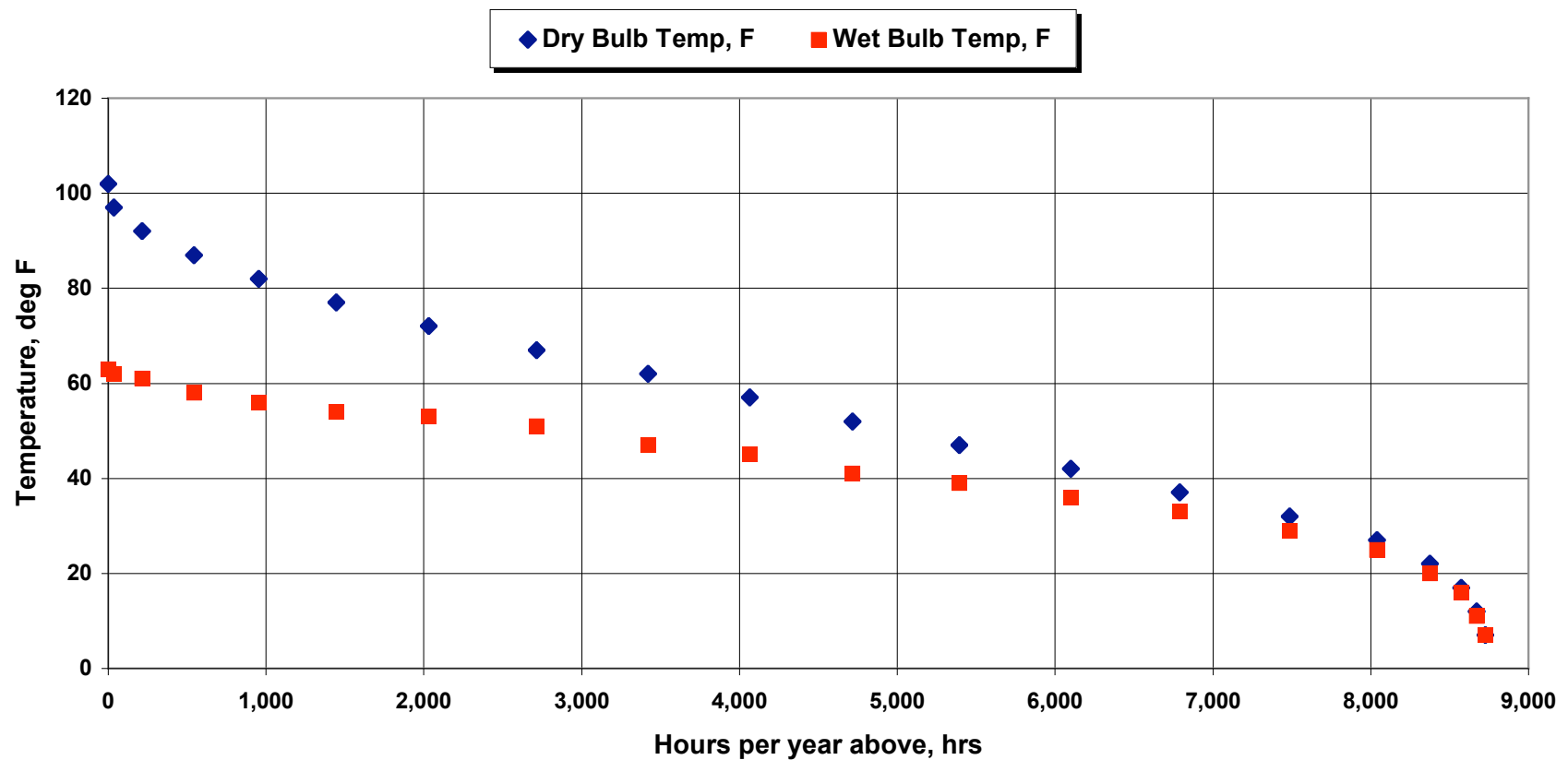


Economic Assumptions

- **Incremental fuel cost**
 - **\$0.40/Million Btu**
- **Cost of power**
 - **\$0.025/kWh**
- ⊕ **Replacement Energy**
 - **\$15/MWh**

Temperature Duration Curves

San Juan Temperature Duration Curves



Supplemental Dry Cooling

- **Install air cooled heat exchangers to take load off existing wet towers**
- **Same concept as Unit 3 but implemented as separate structures**

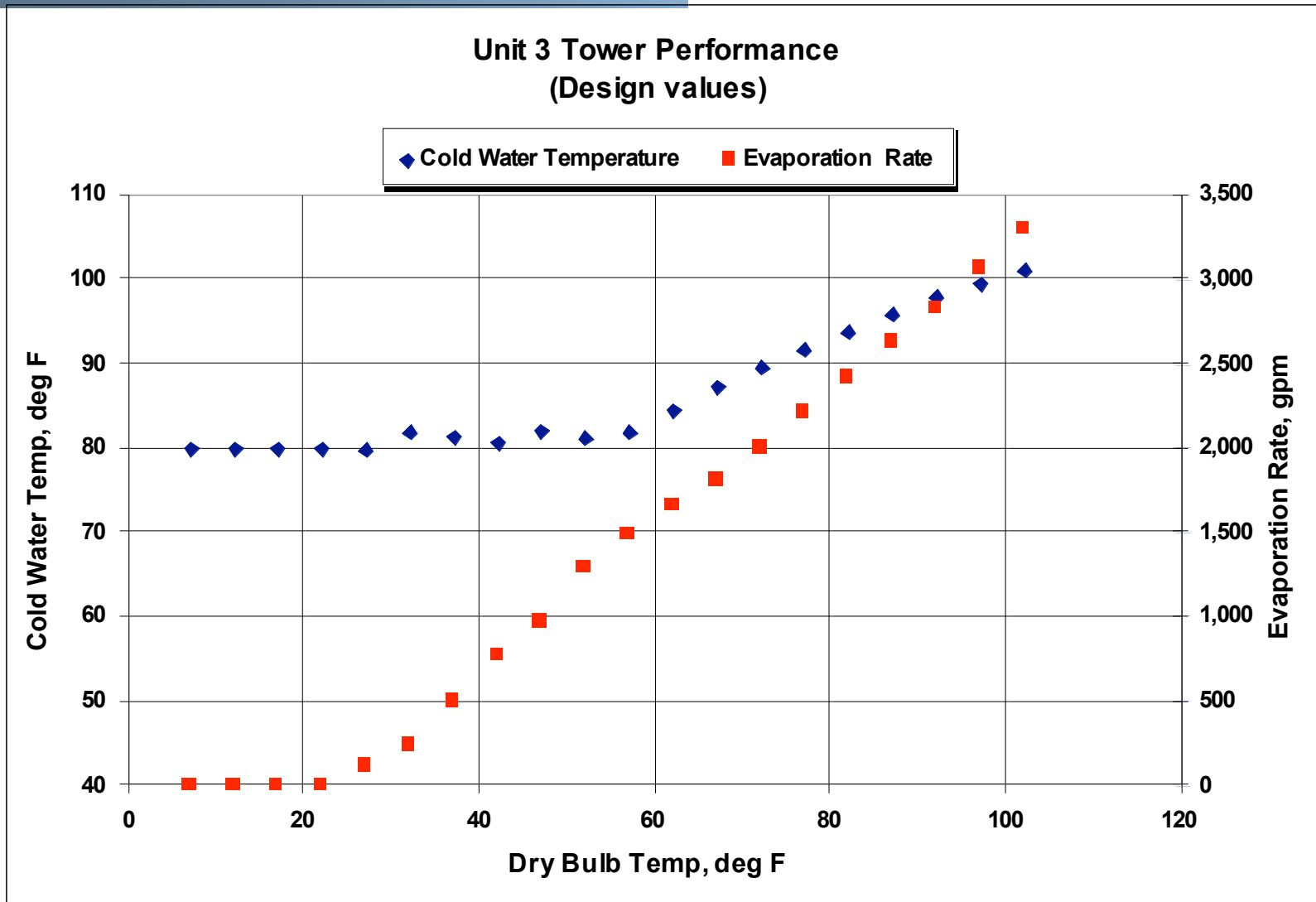
SJGS Unit 3 Cooling Tower



Unit 3 Example

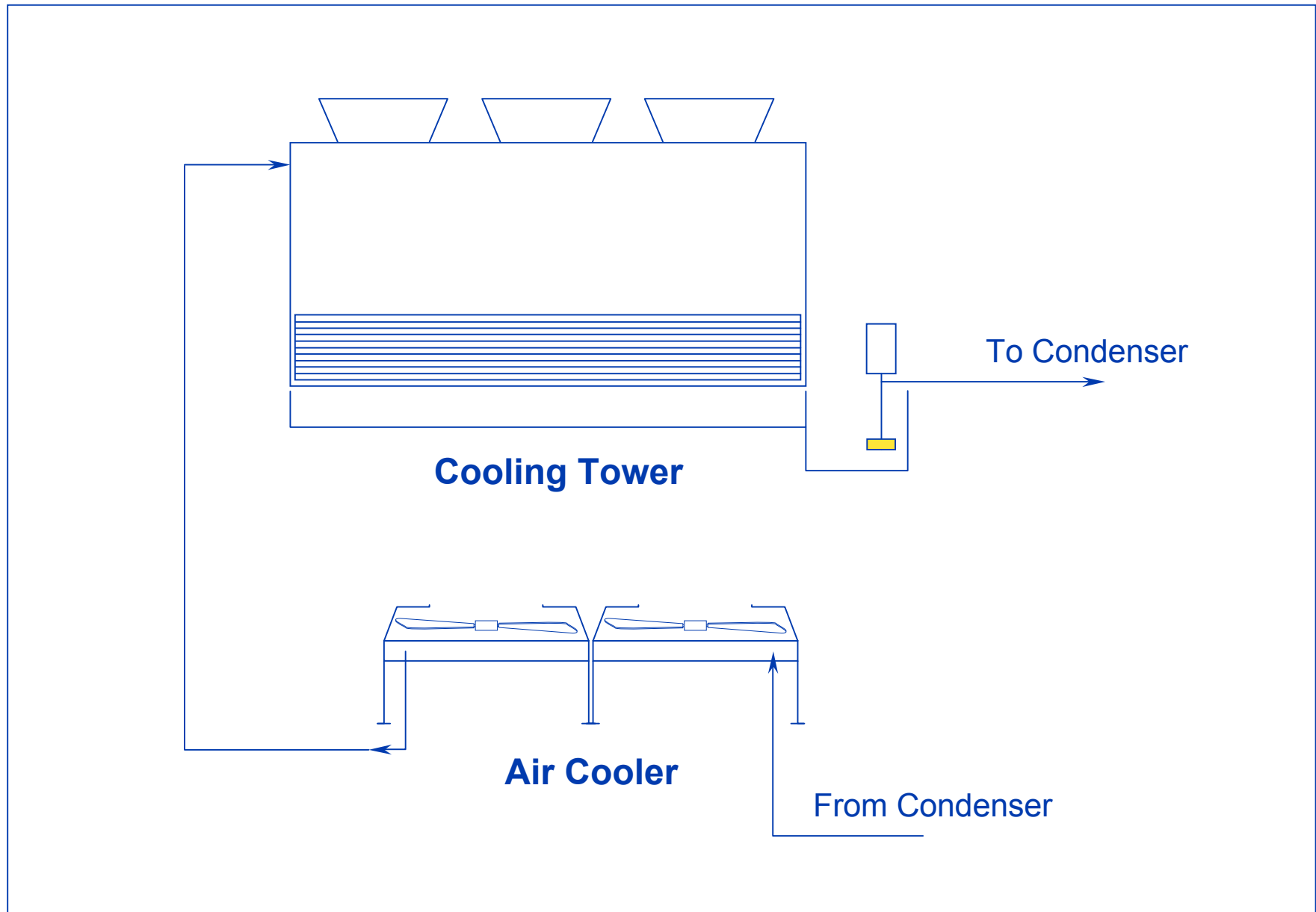
- **Series arrangement**
 - **Modulated wet section**
- **Annual water savings of 70%**

Unit 3 Performance



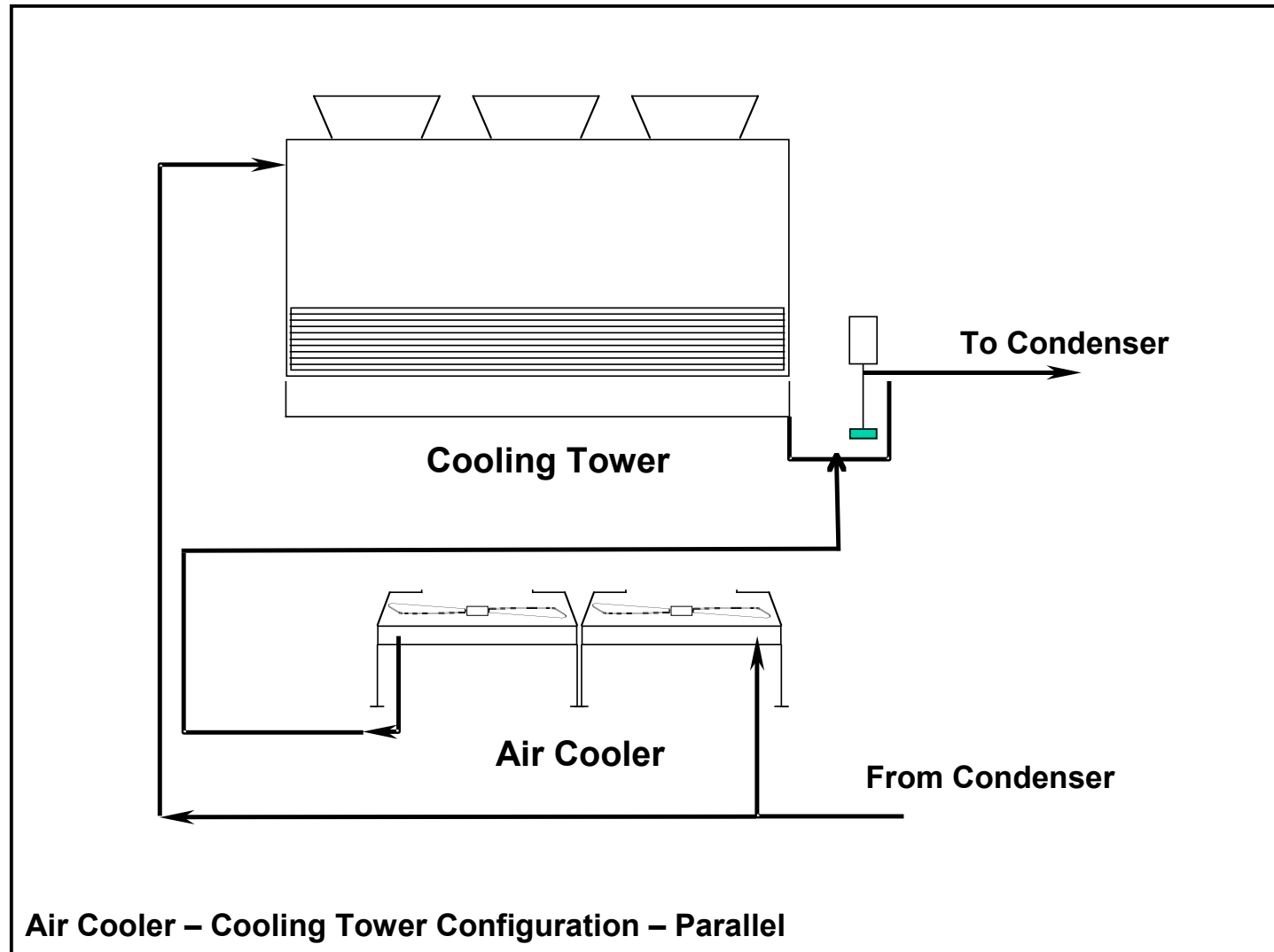
Options—Design & Operation

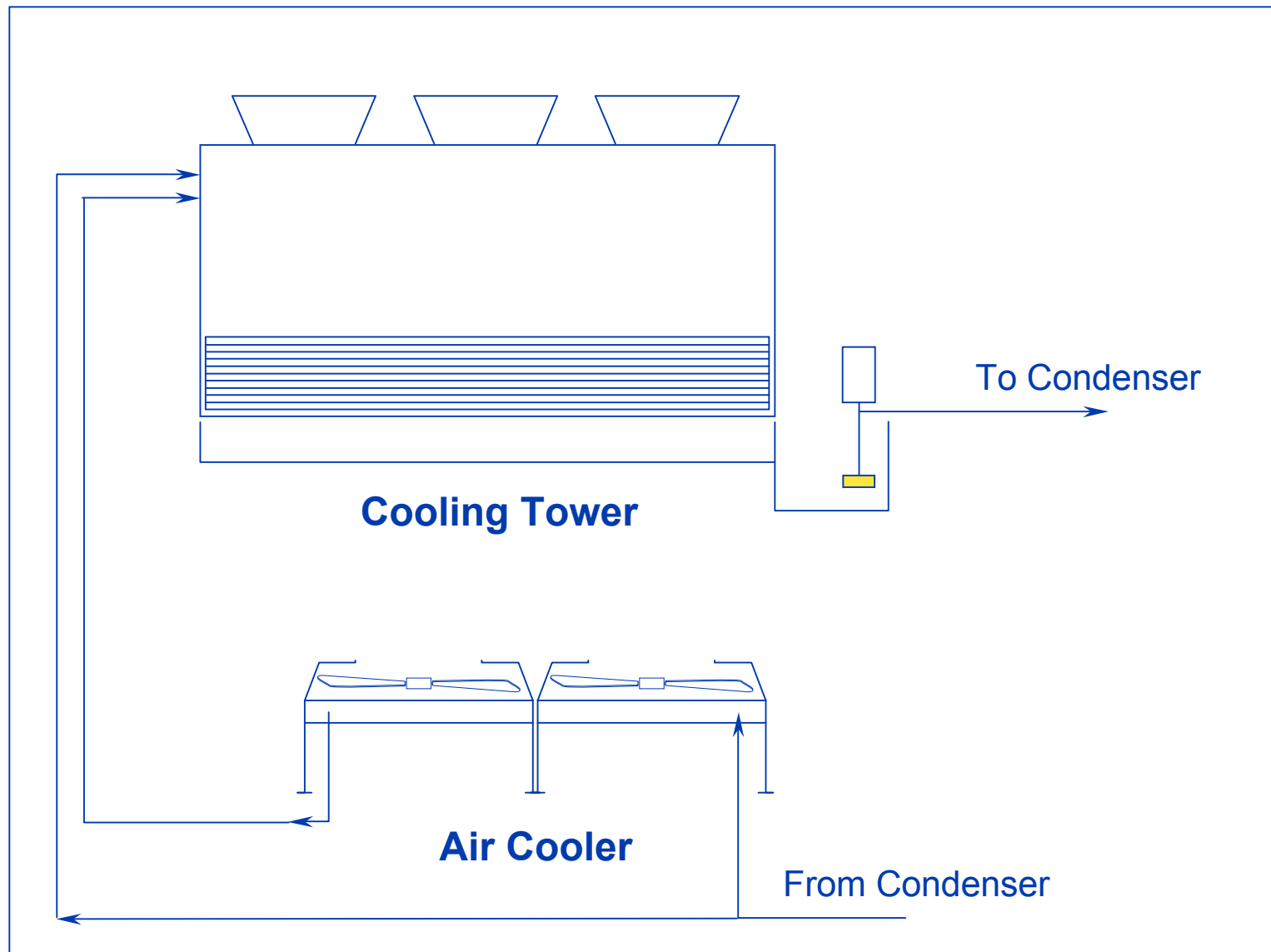
- **System arrangements**
 - **Parallel, series, split series**
- **Wet tower operation**
 - **Full on or modulated**
- **Dry exchanger operation**
 - **By-pass/fans off during hottest hours**
 - **Freeze protection**



Air Cooler – Cooling Tower Configuration - Series

Parallel Arrangement





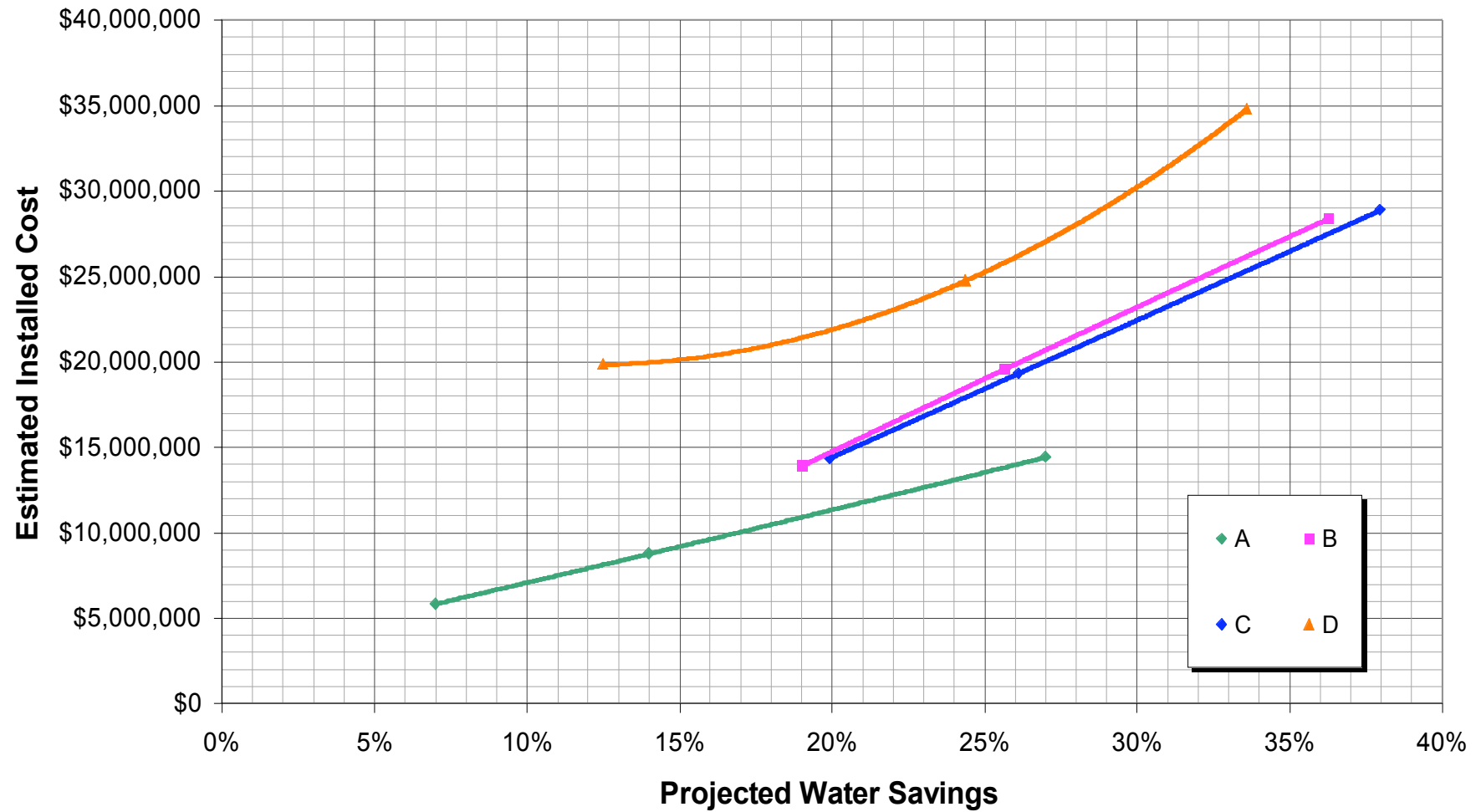
Air Cooler – Cooling Tower Configuration – Split Series

Options

Source	Arrangement	Wet Tower Operation	Cold Water Delivered
A	Series	Modulated	Design temperature 80 F year round
B	Series	Full	Close to current profile
C	Series	Full	Close to current profile
D	Split series	Modulated	Match current profile
E	Various	Various	Various--similar to Unit 3

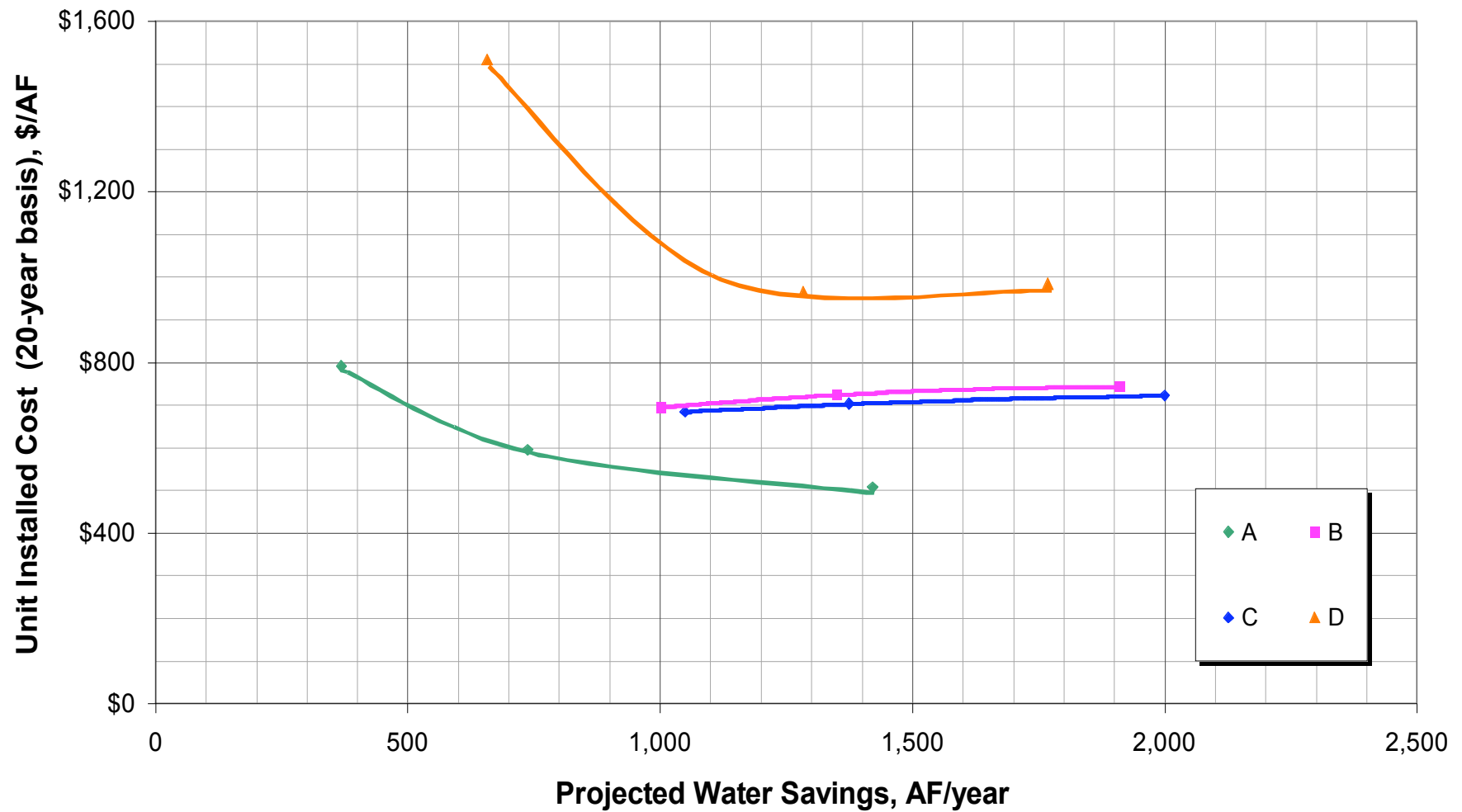
Installed Cost vs Water Savings

Unit 4, San Juan Generating Station



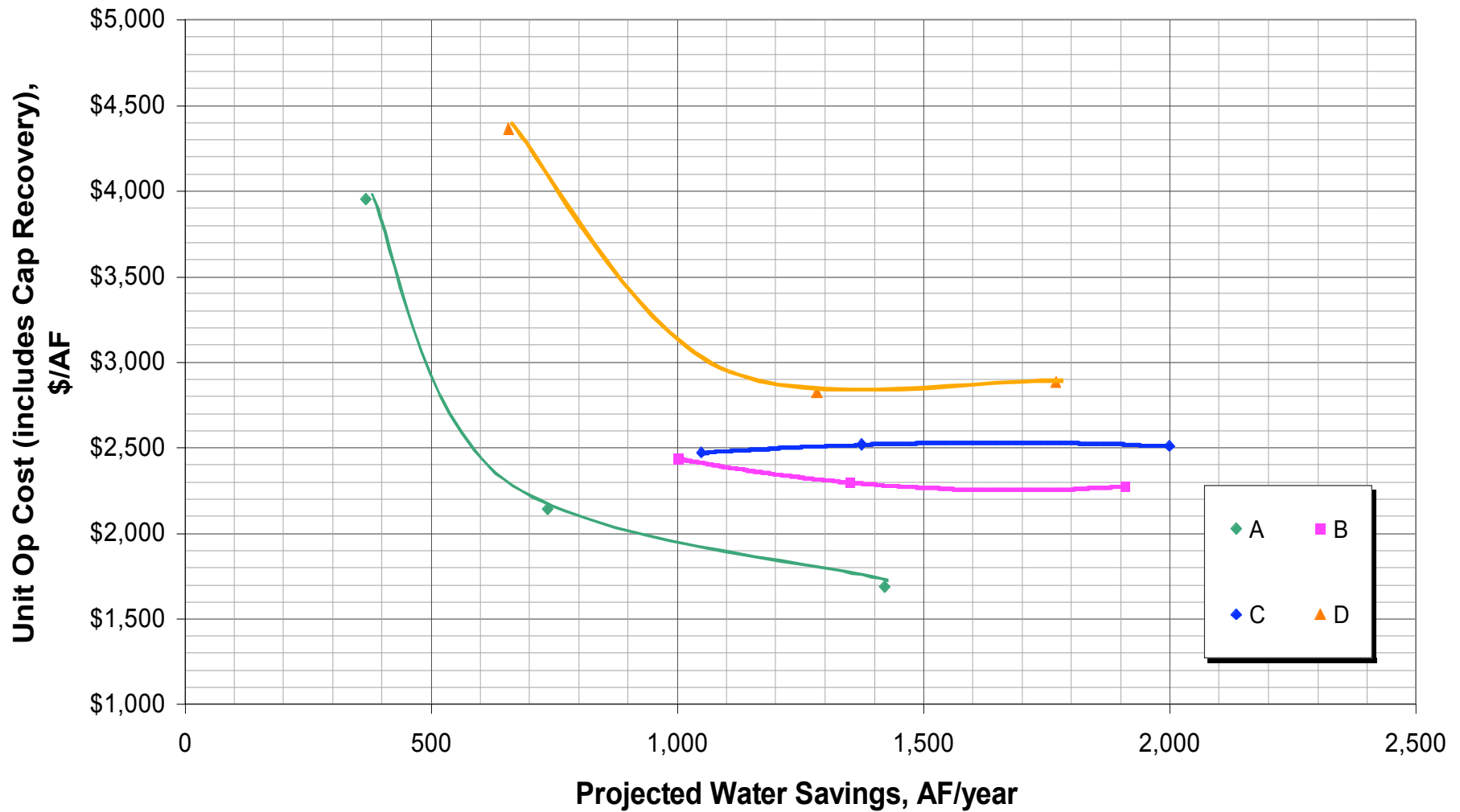
Unit Installed Cost vs Water Savings

Unit 4, San Juan Generating Station



Unit Op Cost vs Water Savings

Unit 4, San Juan Generating Station



Summary Comparisons for Unit 4

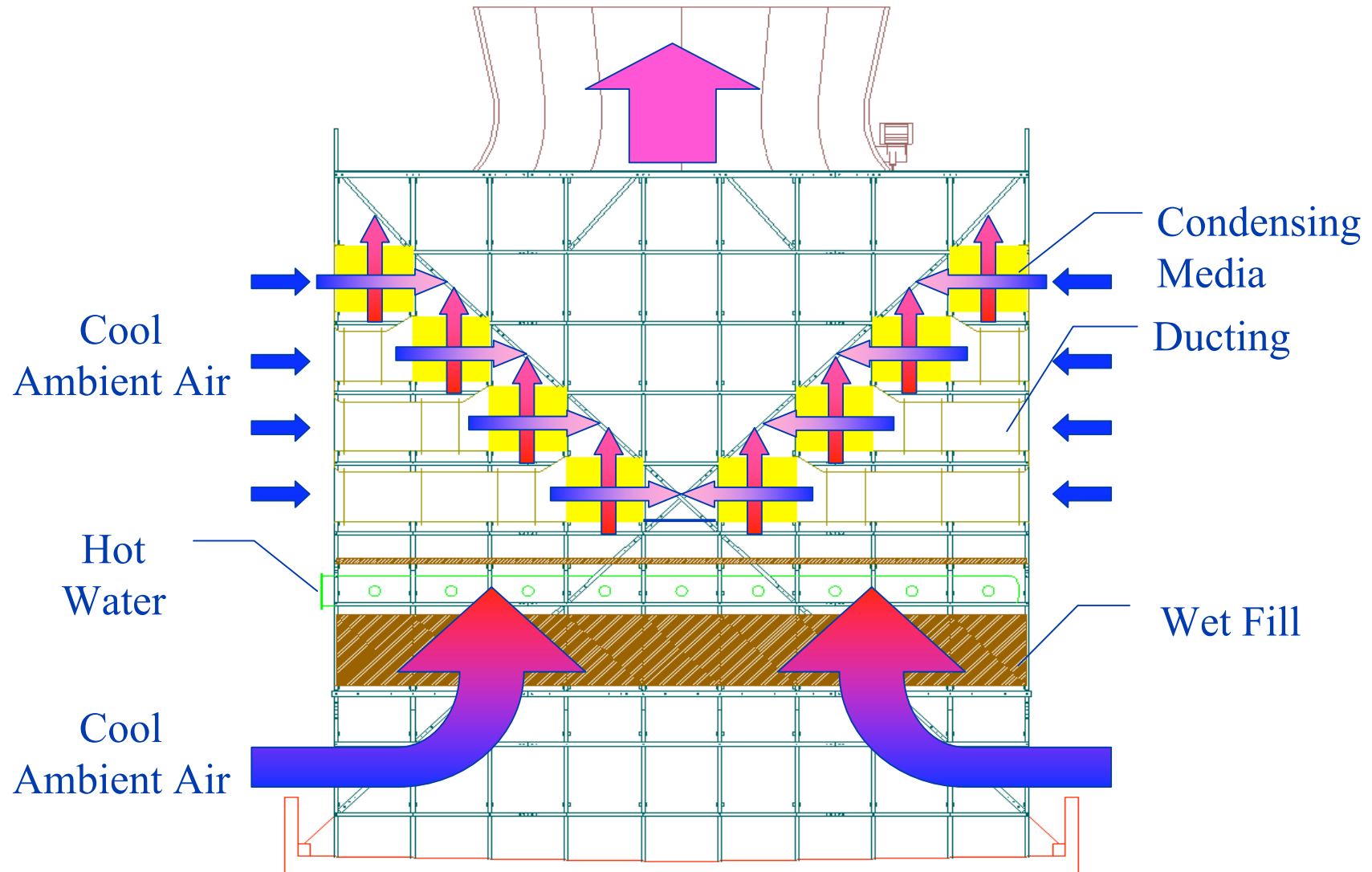
San Juan Generating Station

	Supplier			
	A	B	C	D
Configuration	Series	Series	Series	Split
Water Savings, %	27.0%	25.7%	26.1%	24.4%
Water Savings, AF/yr	1,422	1,351	1,375	1,284
Water Savings, AF/yr/MW	2.6	2.5	2.5	2.3
Foot Print Area, sq. ft.	43,056	44,425	42,336	39,585
AC Fan Power, HP	3,200	3,588	4,400	4,054
Add'l Pumping Power, HP	236	1,086	1,005	640
Wet Tower Power Reduction, HP	-1,074	0	0	-754
Total Add'l Power, HP	2,362	4,674	5,405	3,940
Avg Cold Water Temp, F	80.0	68.7	68.7	67.4
Avg Backpressure, "Hg	2.57	1.88	1.88	1.77
Avg Heat Rate Increase, %	0.17%	0.01%	0.01%	0.00%
Add'l Coal Consumed, TPY	3,444	249	249	0
Equipment Cost	\$4,000,000	\$6,818,000	\$6,401,000	\$9,290,000
Total Installed Cost	\$14,410,000	\$19,562,000	\$19,306,000	\$23,232,000
Power Cost @ \$0.025/kWh	\$297,000	\$587,000	\$679,000	\$495,000
Power Replmt Cost @ \$15/MWh	\$178,000	\$352,000	\$407,000	\$297,000
Maintenance	\$479,000	\$243,000	\$479,000	\$288,000
Add'l Coal Consumption	\$29,000	\$2,000	\$2,000	\$0
Capital Recovery @ 7.5%	\$1,414,000	\$1,919,000	\$1,894,000	\$2,279,000
Annual Operating Cost	\$2,397,000	\$3,103,000	\$3,461,000	\$3,359,000
Unit Op Cost, \$/AF	\$1,686	\$2,296	\$2,517	\$2,615

Summary

- ✓ **Water savings of 20 to 30% are achievable**
- ✓ **Costs depend on meteorology and desired cold water temperature**
- ✓ **Most economical with**
 - **flat heat rate curve**
 - **low fuel cost**
 - **low projected value (or replacement cost) of power**
- ✓ **Equivalent cost of water is very high**
- ✓ **Sometimes water is “not there at any price”**

Marley AAHE-- New Tower



AAHE--Retrofit

